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November 13, 1855.

JAMES SIMPSON, President,
in the Chair.

No. 929.—"On the Construction of Stationary Floating Bodies."[1]
By GEORGE HERBERT.

THE best form for buoys has been long under consideration at the Trinity House, and it is really a subject of such importance, as to demand more careful investigation, than it has hitherto received from scientific men and Civil Engineers.

The form and construction of the buoys, ordinarily in use, are so well known, that it will be sufficient merely to point out a few of the chief objections to them. The distance of the point of attachment from the centre of gravity, will account for the instability of those buoys in a heavy sea, as well as for the extraordinary strength, which is required in the mooring chain, to enable such small bodies to maintain their position. Those of the largest size, the displacement of which does not exceed 4 tons, are usually moored by a chain cable, strong enough for a ship having a displacement of 700 tons, yet they nevertheless present such a resistance to the waves as, occasionally, to break links of iron of $1\frac{1}{2}$ inch diameter. The power exerted by the small buoys is equally extraordinary. Their displacement does not exceed one ton, yet they not unfrequently break the links of chain cables of iron $\frac{7}{8}$ths inch in diameter.

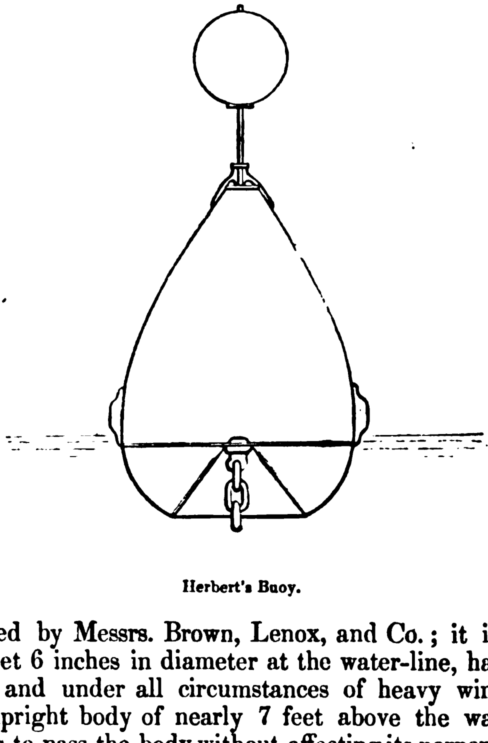
In order to obviate these casualties, and, at the same time, to enable the buoys to retain a more uniformly erect position, it was proposed, that the mooring chain should be attached near to the centre of gravity and to the centre of the plane of flotation, which

[1] The discussion upon this Paper extended over portions of two evenings, but an abstract of the whole is given consecutively.

points should be nearly identical, and it was considered, that the easiest mode of attaining this, was by raising up and hollowing out the bottom of the buoy, to about the surface of the water, and near to the apex of the hollow cone thus formed, to attach the mooring cable. In practice it is found, that the action of the sea upon buoys, thus constructed and moored, is very different to that which takes place upon those of any other form.

Fig. 1 is a section of one of these buoys, of wrought iron,

Fig. 1.



Herbert's Buoy.

manufactured by Messrs. Brown, Lenox, and Co.; it is 9 feet in length, 6 feet 6 inches in diameter at the water-line, has 2 feet of immersion, and under all circumstances of heavy wind, or sea, shows an upright body of nearly 7 feet above the waves. The tide appears to pass the body without affecting its perpendicularity, for whatever pressure is exerted upon the outside of the buoy is, to a great extent, counterbalanced by nearly as great pressure on the opposite side of the inner raised cone of the bottom. This is confirmed by the report of Mr. H. B. Disney, of Lowestoft, a very experienced North Sea pilot, who, in a report upon it, states, "I, yesterday morning, on my passage up the Swin, had an opportunity of observing the difference between the N. E. buoy of the Gunfleet (Fig. 1), and others in the same locality. The principal

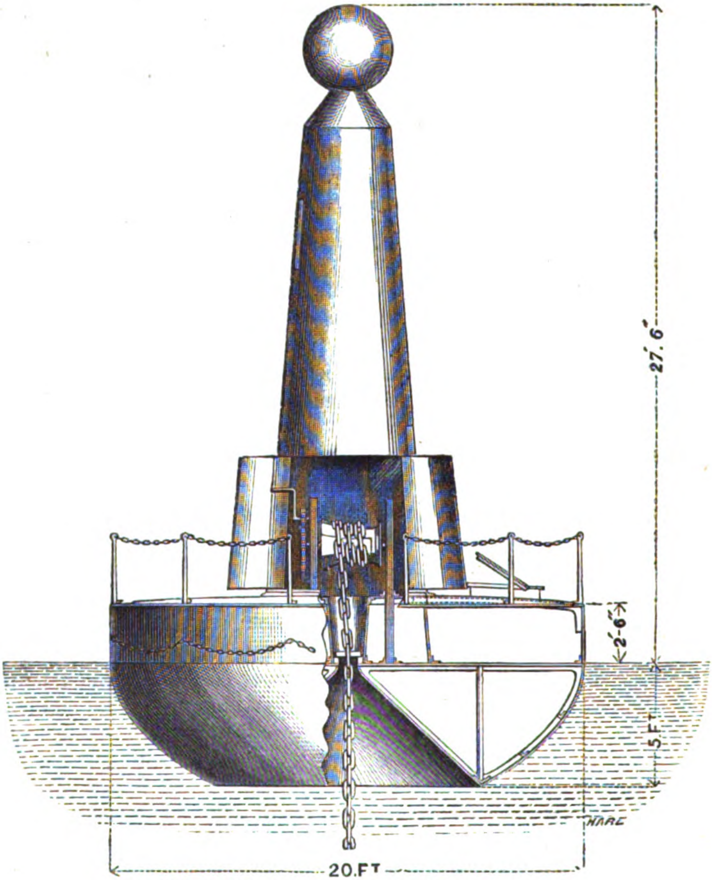
one to which I directed my attention, was the large Beacon buoy upon the S. W. end of the Shipwash. The wind was blowing fresh from the eastward, with a quick chopping sea and the commencement of a spring tide; the above buoy was inclined from the perpendicular at an angle of not less than 30°, and frequently more, the effect of wind and tide causing it to plunge and alter its angle in short and rapid movements. The N.E. Gunfleet Buoy had a very slight inclination,—so slight that a casual observer would have pronounced it perfectly upright,—stemming the tide perfectly at ease, it apparently having no effect whatever upon it. I passed the above buoys at the same distance of rather more than a mile, and the opinion I formed, from observation, was the decided superiority of the Gunfleet Buoy; whilst the S.W. Shipwash Buoy seemed in danger of breaking adrift, the other rode perfectly tranquil and with the greatest ease."

Buoys of the ordinary construction, have not hitherto been made of larger size than 4 tons, as from experience, it was presumed, that they would require such very powerful chains and moorings to hold them; this objection could not, however, be urged against buoys, or other sea marks, constructed upon the principle now under notice.

In the course of last year, the Trinity House ordered the construction of a buoy, or sea beacon, of 30 tons displacement. (Fig. 2.) This beacon, which was made of wrought iron, was 20 feet in diameter at the water-line, with a tower of 7 feet diameter at the base, and had an immersion of 4 feet 6 inches; whilst the top of the ball, surmounting the tower, was 27 feet 6 inches above water. The base upon which the tower stood, was divided by radiating bulk-heads, into six water-tight compartments, with a deck upon the water line, the space between the lower and upper deck being also divided into four water-tight compartments. The mooring chain was held by a toggle, passed through one of the links, some little distance up the hawsepipe, and then passed round the windlass within the tower. The thickness of the outer plates was $\frac{1}{4}$th inch, that of the hawsepipe $\frac{3}{8}$ths inch, and of the tower $\frac{3}{16}$ths and $\frac{1}{8}$th inch. This beacon was moored in 7 fathoms water, at the South Sand Head of the Goodwin Sands, in the midst of the overfall of the sea, and it would be difficult to find a situation where it could be subjected to a severer test. The manner in which it rode at that trying station, for five weeks, during very severe weather, is well described in the following extract from a letter from the Master of the South Sand Head Light-vessel, within one mile of which the beacon was moored. He says, "I here give you my opinion, as near as I can, from what I have seen while watching it. The tide does not seem to have any particular effect upon it, to cause it to sheer about, or to give it a

list, or to turn it round, more than a vessel; the wind cannot affect it to cause it to roll. Its motion is quick and caused by the waves. Its motion depends on the heave of the sea, whether it is

Fig. 2.



Sea Beacon.

a short breaking sea, or a long bowling sea; in a short breaking sea, its motion is the greatest. The angle made by it, is not so great as the waves it rides in. When I was upon it, I could not perceive any tugging motion on the moorings. It turns round as a vessel would do with the tide, that is to say, it follows the tide round. I could not distinctly see whether the sea washed over the deck, but I should think it did; there was not, however,

any heavy breaking sea against the tower, if so, I should have seen it. I should think it rolled out of the perpendicular about 5 feet, as near as I can guess."

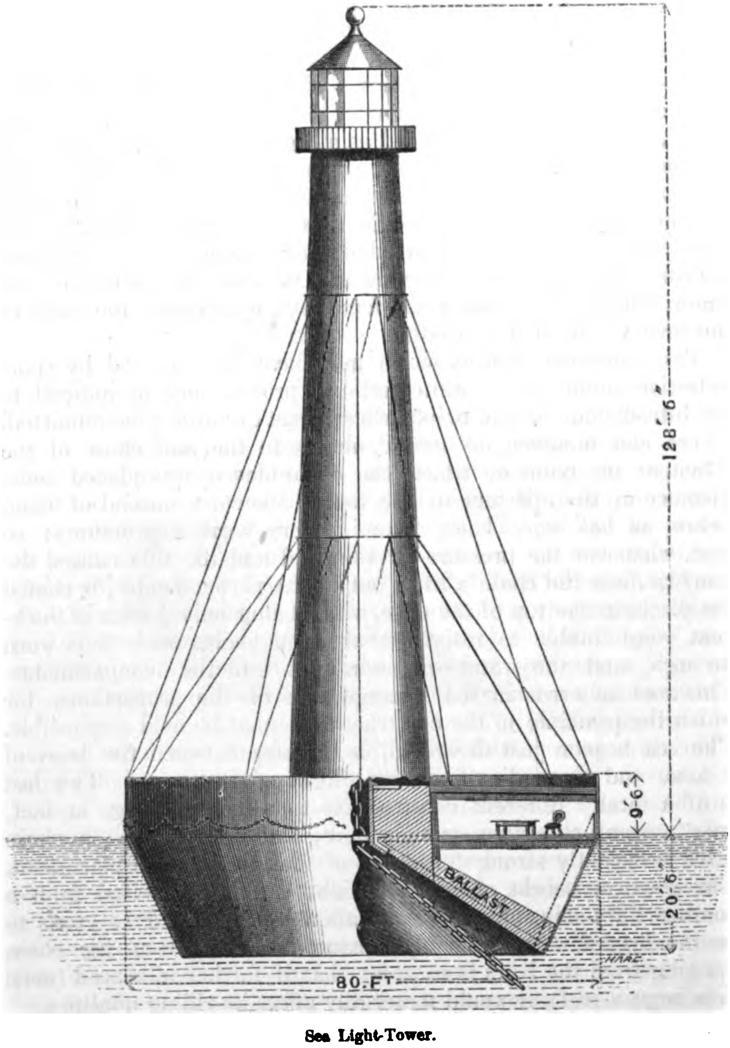
It is evident from this letter, which bears important testimony in favour of the principle, that neither wind, nor tide had any prejudicial effect upon the steadiness of the beacon, and that the waves alone affected it, causing it to incline not more than 5 feet, or 10° from the perpendicular, and this with a draught of water of only 4 feet 6 inches, so that it was affected by all the surface movement of the waves, by which a larger body, drawing more water, would not be influenced. So fine a sea mark as this beacon, has, it is believed, never before been afloat, and that it should prove itself so steady, and remain so upright in the overfall of the South Sand Head, cannot but be regarded as a highly successful result. As has been stated, it encountered some violent weather, during the five weeks it remained at its station, and at the end of that time, during moderate weather, without any apparent cause, it was observed to have become lop-sided; it remained in that condition for three days, and then fell over and lay upon the surface of the water, where it continued for four days, and during the night of the seventh day it disappeared.

This apparent failure, which may have been caused by some defective joints in the structure, has proved very prejudicial to the introduction of a principle, which must eventually be admitted. There can, however, be little doubt as to the real cause of the disaster; the point on which the cable moved, was placed some distance up the aperture in the top of the cone, instead of being below, as has since been done in more correct structures; so that, whenever the pressure of the wind and the tide caused the buoy to draw the chain a little out of the perpendicular, it chafed the plates at the top of the cone, which being only $\frac{1}{4}$ inch in thickness, were unable to resist the abrasion; holes were thus worn through, and the water was admitted into the compartments. This was an error in the arrangement of the proportions, for which the principle of the construction cannot be held responsible. The sea beacon just described, is the step between the buoy of 4 tons, and the ordinary floating light of 180 tons. This last is of a totally different construction to a buoy, being, in fact, only a small ship very strongly built, and moored with a chain cable sufficiently strong for a ship of four times its displacement. The greatest height at which a light can be exhibited from a floating light-ship, appears to be about 38 feet, and 180 tons to be the largest size, probably because the weight of the chain hanging from the bows is so great, that if further increased (even in a large vessel), it would materially affect its riding qualities.

It would appear practicable to adapt this new system to the

construction of Sea Light-Towers, to be substituted for the present light-ships, and in submitting to the Trinity-house the design for a floating light-tower of this description, Sir Charles Fox (M. Inst. C.E.) expressed his belief, that wherever such a structure was placed, and whatever weather it might be exposed to, it would maintain its erect position. The plan of the light-tower, as arranged and calculated by Mr. E. A. Cowper (Assoc. Inst. C.E.),

Fig. 3.



Sea Light-Tower.

and submitted by Sir Charles Fox, is shown in Fig. 3. This sea light-tower is proposed to exhibit a light, 125 feet above the level of the sea. The circular base, which supports the tower, is 80 feet in diameter, and the draught of water is 20 feet. The tower is 24 feet diameter at the water-line, and the lantern is 14 feet, with ample room for the use of either the dioptric or catoptric system of illumination. The light-house is proposed to be constructed entirely of wrought-iron plates, and to be weighted with 1,032 tons of ballast. The weight of the tower and lantern is 117 tons, the displacement of the whole structure being 1,602 tons; the weight of the tower, &c., is, therefore, about the same as that of the masts, spars, blocks, sails, rigging, &c., of a ship of 1,600 tons. The centre of gravity of the entire structure, is 2 feet 6 inches below the surface of the water. The weight of a double mooring-chain, composed of two lengths of $3\frac{1}{2}$ inch chain-cable, will, in a depth of 30 fathoms, and under the greatest pressure of wind and tide, be 46 tons, and the catenary curve will, under the same circumstances, be about 47° from the perpendicular. Each of these chains will have been tested with a pressure of 200 tons, and the extreme strain to which they will be subjected afloat, will not exceed 92 tons. The security of this structure depends upon its moorings, which may be either a very ponderous sinker, or, within certain limits of depth, Mitchell's screw-moorings, but the construction is such, that if the chains be not considered sufficiently strong, any additional weight of chain, or number of screw-moorings, may be added; if 100 tons more cable were used, it would only be necessary to take out that amount of ballast. In the event, however, of any unforeseen occurrence causing the sea light-tower to break adrift from its moorings, it would have (also passing through the top of the cone) a spare chain ready for letting go, and an anchor, or sinker of very great weight attached to it, and kept in the tower, ready to be run out upon a tramway, and be shot over the side, the chain having been previously permitted to run out from the top of the cone, to the required length.

The three powers with which this light-house will have to contend, are the Wind, the Tide, and the Waves. The power of the wind has been estimated at from 30 lbs. to 40 lbs. upon the square foot of the round surface of the tower; this extreme pressure will not exceed 34 tons, and will not cause the light-house to incline from the perpendicular more than 1° 28′. The speed of the tide has been taken at four miles per hour, causing a pressure of 30 tons upon the immersed part of the sea light-tower, making a total pressure of 64 tons, arising from the combined force of the wind and tide. With regard to the waves, it will be necessary to ascertain the height, length, and speed of them, to know the angle and the

rapidity of the oscillations that the light-tower would be subject to. As very little is known of their conjoint height, length, and speed, some observations made by Mr. Nicholas Douglass, the Superintending Engineer of the light-house building on the Bishop Rock, the westernmost of the Scilly group (off the Land's End), may be of value; and they bear upon the point under consideration. Mr. Douglass has been engaged at the Bishop Rock for the last seven years, and he has not only the experience, but also the nerve and the judgment, to be able to form a correct estimate of the movement of the waves. The following is the result of a series of observations made by him in 1853, at the request of the Author, and of the accuracy of which there can be no reason to doubt, viz., that generally the waves at the Bishop's Rock, having a height of—

8 feet	from hollow to crest,	number	35	in one mile, and	8	per minute.
15 feet	,,	,,	5 & 6	,,	5	,,
20 feet	,,	,,	3	,,	4	,,

The two first observations were made from the Rock, and were estimated by means of a reef, three-quarters of a mile distant. The last, or those upon the 20-feet waves, which are the highest he has observed there, were made from a vessel. The waves are described as being generally one-third plane, or level, one-third rising to the crest, and one-third falling again to the plane, or level. There will, of course, be in waves of 15 feet and 20 feet height, a great deal of surface movement, independently of the main undulation, but there cannot be sufficient to have much effect upon so large a body as the base of this sea light-tower, which would ride upon each wave. It does not appear that either the angle, or the frequency of the waves at the Bishop Rock, the most exposed situation on the coasts of Great Britain, would prove in any degree detrimental to the structure; and it will be observed, that the point where the mooring is attached, has scarcely any lateral motion, in consequence of its being close to the centre of gravity.

It is submitted, that the sea light-tower will prove very useful for marking shoals, or rocks, or islands, which are difficult of access. There are many positions where light-towers of this construction might have been adopted with public benefit, and there doubtless remain many others, where it may be advantageously brought into use; as light-houses in such situations, are generally required as warning rather than as guiding lights; thus it usually matters little, whether the light-house be exactly upon the point of the rock, which it is intended to warn a vessel to avoid, or whether it be within a short distance of it, so that the locality of the danger is made manifest.

The light-house on the Skerryvore Rock occupied seven years in construction, and cost upwards of £80,000. The same object, that of marking the Skerryvore Rock, by a light exhibited 150 feet above the sea, might, under the proposed system, be attained at an expenditure of about £30,000, and within one year after the commencement of the construction. The position of the Bell Rock might be marked at a cost of about £20,000, instead of £60,000, and that of the Edystone at about £15,000, instead of £40,000, and the sea light-towers so placed, would possess the great advantage of being accessible in all weathers.

As a guiding, or fairway-light, this mode of construction may be very advantageously used. The problem of exhibiting a light of any altitude in a very deep water channel, has not hitherto been solved, and consequently the vast majority of the lights are not those that lead into a right course, but those that warn from a wrong one; and so long as this remains the case, the lighting system is essentially one-sided and defective. In the entrances to the principal channels, such, for instance, as the St. George's Channel, the mariner, when right, has, as yet, had only the negative assistance of assuming, that, if he sees no lights, he is somewhere out of danger; thus the lights on shore are a constant invitation to the doubtful sailor to approximate towards mischief, in order that he may discover its existence; but a fairway, that is to say, a guiding light, upon the construction just explained, being capable of being moored where there is a depth of water of 60, or 70 fathoms, can be placed midway in deep wide channels, as an invitation to the right course, and thus insure to all vessels a safer and speedier navigation.

The observations, now brought under notice, are limited to sea-marks, but if the principle of construction be correct, it will be equally applicable to floating batteries, &c., and to every other description of stationary floating body.

The Paper is illustrated by diagrams of the buoys, the sea-beacon, and the proposed sea light-towers, whence the wood-cuts (Figs. 1 to 4), have been compiled.

[Captain Washington,

Captain WASHINGTON, R.N., said, the reports he had received of the qualities of the buoy of the new form, at the Gunfleet and other places, were most favourable; they remained erect and steady in very heavy weather, where those of the ordinary construction were generally buried under the waves, and not unfrequently broke from their moorings. A steady seamark was an inestimable boon to mariners. There were many positions where it was difficult to place fixed lights, and therefore recourse was, of necessity, had to light-ships: they were, however, liable to casualties; some years since, he had seen three light-ships adrift at the same time in the North Sea. Now if this principle of a circular form had been already, with some appearance of success, extended to beacons, there was reason to hope it might eventually be adapted to carrying lights. He admitted, that mooring near the centre of gravity, appeared to be correct in principle, and it was highly desirable that it should be submitted to such a practical test, as would be afforded by placing one of these lights, of a moderate size, on some exposed position, probably on the South coast of Ireland. The spot should be carefully selected, so that no fatal consequences might ensue, if the sea-light should break adrift.

Mr. A. GORDON said, he conceived that if a buoy could be so constructed, as to preserve an upright position in a gale of wind, or in strong currents, it would be very possible to keep a sea-light erect, under the same conditions. If the height attained was only that of the light in ordinary floating light-ships, it would still be an important improvement. There could be no doubt of the correctness of the principle of mooring, insisted on by Mr. Herbert; but he submitted whether, if, instead of putting ballast into the lower part of the floating body, that weight was added to the mooring itself, it would not tend to render the sea-light less liable to break adrift. Neither could there be any doubt of the correctness of the conical form, at the interior centre of the base; but it might be a question, whether the exterior form could not be improved. The body under discussion, not being a ship, but a strong floating buoy, intended for retaining its position at its moorings, or at anchor, there need not be any of the lines which distinguished the midship sections of sea-going vessels. Mr. Gordon would, therefore, prefer the outward midship section being like the frustrum of a short cone, with a broad base, or bottom below the water. A mass of fir-wood, in the form of a cone, with a base of 5 feet diameter, and an altitude of 3 feet, would roll very little, if the base was below the surface of the water; but if the base turned above the water, the rolling would be considerable. The reason would be seen at once on a diagram, by drawing both

forms on a line, at a slight angle through the centre of flotation, so as to show the difference of the area of the small angle above water, and that of the angle below water. The mooring of any such body was to be accomplished in the best manner by the interior, or hawse cone shown in Mr. Herbert's system.

Mr. E. A. COWPER believed, that the proposed form of sea-light would offer better conditions of stability, than were to be found in light-ships, as usually constructed. He perfectly agreed, that the principle of mooring from the centre was correct. A vessel, moored from the bows, was continually tugging at the cable, and that action had great tendency to break it: but, if moored from the centre, she would merely rise and fall perpendicularly with the waves. The oscillation was due to the inclination of the wave, but would not be affected by the crest of it.

Mr. Cowper directed attention to a diagram, exhibiting the distribution of the weight (119 tons), of the top gear of a 52-gun frigate, as compared with the weight (117 tons) of the circular tower of the proposed sea-light; from this he inferred, that the latter would be very little affected, by even the heaviest gales.

Captain SIR E. BELCHER, R.N., had proposed a somewhat similar construction in his work on surveying: he had found, that a good-sized cask, with a pole 28 feet high shipped in it, maintained an erect position, so as to serve for a surveying-mark, even in a heavy sea. He doubted, however, whether the proposed sea-lights would stand as securely, or ride as easily in a gale of wind, as one of the present light-ships, if moored from hawse-holes, or tubes through the bottom, situated at one-third of its length. He thought it was probable, that if a heavy sea should strike the upper part of the hull of this new sea-light, and beneath it, at the same moment, the forces being balanced, the mooring-cable would snap. He should like a trial to be made in the Tagus, or in some places where the tide ran from 6 to 10 knots an hour in the freshes. He feared, that under such circumstances, the strain would be sufficient to break the cable. Some years ago, a beacon, moored from the keel, was placed on the King William Bank, in the Irish Sea, and had remained perfectly secure for some considerable period, indeed most probably up to the present time.

Mr. G. HERBERT said, that the action of the waves on such a body, would be entirely different from their action on a ship. The solid water of a wave, striking the hull, would simultaneously fill the cone at the bottom, and its pressure would thus be communicated to the centre, or point of attachment. It followed, that the sea never broke over the base, and that the effect was limited to the production of a vertical motion.

Captain FITZROY, R.N., said, he had every disposition to give the utmost credit to the merit of the principle of mooring from the

centre, as applicable to buoys and beacons, in comparatively still water; yet it must be remembered, that the whole diameter of a lighthouse, or large beacon, was trifling in comparison with the 'send' of a heavy sea in deep water. The whole structure would go bodily with the wave a considerable distance. When the wave had passed, and the water was retiring, the beacon would sink down, dragged by the weight of the heavy mooring-chain: but this movement would be immediately followed by a heavy 'send' back again, and the tendency to break, would occur, just as in a vessel. A ship with a chain-cable, was dragged forward a certain distance, by the weight of the chain, and the next wave threw her back again; so that if the chain was not strong enough, it snapped. When a ship pitched very much, the vertical motion of the water increased the strain; but the great breaking force, was the 'send' of a heavy sea, which, having also acquired a lateral motion, would exercise great vertical force. Supposing that the principle of mooring from the centre, should be found preferable for beacons and buoys, it was quite another question, whether so large a structure as a sea-light, should be erected on a circular body, rather than on a ship-formed body. That shape of hull, which was found to be, the best for advancing through the water, would assuredly offer less resistance to a heavy wave, than a body which would be almost like a ship, broadside on.

He would not enter upon the question of mooring a sea-light in a fair-way channel, as a guide to ships, as opposed to the present system of placing the lights on either side of the channel. The question now to be dealt with, was the principle of the proposed structure. If this form of body was not thought to be the most advantageous, another might be devised; but then, in addition to the question of mooring, which would still have to be considered, there was the problem of the practicability of examining and of changing the mooring-chain. How could anything be done to that chain, without the aid of some power not contained within the structure itself? It was certain that, after some time, the chain must necessarily become corroded, and would require shifting; this appeared to be a serious question. The mooring-cable itself must be of such an enormous size, that its mere weight would induce a strain, scarcely to be supported by such a floating body. On board ships, the hawse was freshened from time to time; there was not always the same link in the hawse-hole; and this shifting not only enabled the vessel to ride very much longer, but prevented the cable from being injured so rapidly by abrasion, as if it were always in one place. The consideration of whether a sea light-tower, placed on a circular body, would not have a greater tendency to inclination from the vertical, than if it were placed on a long body, must of course be carefully examined; because, if the

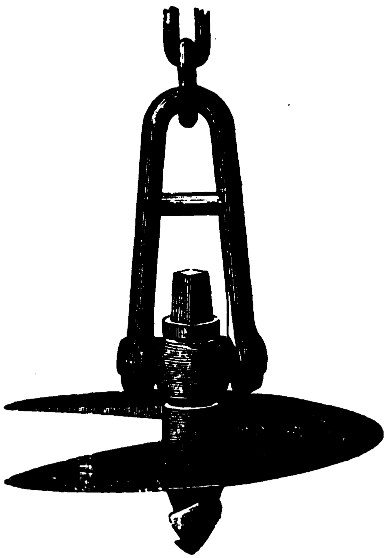
tower was inclined very much by the force of a gale of wind, not only the rays of light would not be thrown horizontally, but, by the oscillation, the oil would be liable to be spilled, and the lights be thus extinguished. In light-vessels, the men could lower the lanterns in bad weather, and trim the lights as often as might be required; but in the proposed structure, this would be impossible, and he doubted very much whether, in a heavy sea, men would be so ready to go up the tower, as they would be to lower down the lights. Sufficient attention was not paid to the glasses, even in lighthouses on shore, and the lights were, in consequence, often exceedingly dim. His impression was, that it would be better to have a light-ship, than any structure of the kind now proposed.

He was sorry that the projector had not brought under notice his application of the circular form, and the system of central mooring, to floating batteries of large dimensions. In them, the principle would come into play most advantageously, and the objection of the resistance it offered to the run of the sea, and to the wind, would not apply. They would be employed chiefly in shallow water, and, being moored from the centre, would prove remarkably steady. On the whole, his opinion, as a practical man, was, that for small beacons and buoys, the invention was very useful, and that it would be excellent for floating-batteries, but that it would not be found so advantageous, when applied to sea-lights.

Mr. G. Herbert remarked, that arrangements were made for changing the bearing-links of the cable, and for hauling it up when required; for these purposes, a powerful crab, or winch, was fixed inside the tower of the beacon. In a sea-light, there would be much more space and greater facilities, for providing for all these technical wants. The question of the applicability of the new form to floating-batteries, had only been slightly alluded to in the Paper, because it had not been tried; but it must be evident, even to the comprehension of landsmen, how many advantages it offered; and as it was now recommended by eminent naval authorities, he hoped that it would be tried. He had prepared a design for the adaptation of the principle to that kind of structure, but he wished, at present, rather to confine the discussion to the adaptability of the system to buoys, beacons, and sea light-towers. The security of a sea light-tower would depend upon its moorings, which, for greater certainty of holding, should probably be Mitchell's screw moorings (Fig. 4), within certain limits of depth, and if a chain weighing 46 tons was not considered sufficiently strong, any additional strength might be added, and would only have the effect of immersing the floating base a few inches more; or a powerful ground chain could be

screwed down, and the beacon, or sea-light could ride by a bridle chain, which could be shifted and examined as might be requisite.

Fig. 4.



Mitchell's Screw Mooring.

Captain POULTER agreed as to the utility of the new buoys, but doubted whether the principle could be safely extended to sea-lights. There were many difficulties to be overcome, such as the stowage of the heavy cable, and the running out of a second anchor, in case of breaking adrift; and he feared that the ballast, if placed at the bottom of such a vessel, would capsize it. The mooring-chain, after some few years, would require to be renewed, and this, he understood, was proposed to be effected by a winch inside, which he must, from his experience, pronounce to be impracticable. The rolling and pitching of such a sea-light, would render the direction and force of the lights very uncertain. He was altogether opposed to placing guiding-lights in mid-channel: a vessel might run foul of them, and be lost; or the structure itself might be injured by collision, and the lights not appearing, might become a source of danger to mariners.

Captain MOORSOM said, that as experience had shown the small buoys to answer exceedingly well, there was no reason to doubt the success of larger vessels, constructed on the same principle. He was rather disappointed in the views of the subject, taken by the nautical gentlemen; they did not seem to have rightly appre-

hended the mechanical position. The cross section of the bows of a large vessel, experienced an impulse from a sea, in proportion to the exposed area; and this impulse was neutralized by the vessel dipping her aft section. It was evident to him, that the right point of attachment must necessarily be at the centre of oscillation, that centre being as near as possible to the centre of gravity. He did not apprehend there would be any great mechanical difficulty, in renewing the chain whenever it might be required. The Britannia Bridge had been raised, and it might be requisite, at some future period, to renew the structure, and he apprehended, that the same mechanical ingenuity which had accomplished the one task, would not be wanting, when it was required to effect the other. He did not think that the proposed form of base, was the best that might be devised; he considered that a more conical shape would be found to adapt itself better to the rise and fall of the wave; and if the base were more extended, it would give greater stability. Mr. Herbert had, however, propounded the right principle, and was entitled to their best thanks.

Captain Sir E. Belcher, R.N., said, that a cutter, in a gale of wind, pitched her mast from 17° to 18° out of the perpendicular. Now if the sea-light were held by the centre, and floated horizontally on the surface of the wave, it would, under sudden influence, necessarily incline as many degrees as the wave itself; and if, at that moment, it should be struck by a sea, above its point of equilibrium, it would probably capsize. He saw no difficulty in changing the chain, for this he had himself done in very bad weather. The depth, however, must not be too great: a ship of war had great difficulty in recovering 60 fathoms of chain, hanging at a dead nip on her hawse, and when it reached 100 fathoms, was not unfrequently compelled to slip her chain-cable even in calm, or fine weather.

Mr. J. Scott Russell said, that as far as the form was concerned, no doubt a sea-light of the proportions and shape exhibited, could be kept upright in tolerably smooth water; but then the question arose, whether in a rough sea and strong current, it would be advisable to have a form, which might be said to be always broadside on, and whether anything had yet been invented, to moor it steadily in deep water. He himself knew of no means by which a man-of-war could be held broadside on to the pressure of a gale of wind. He would be inclined to give to a light-ship great length, with a safe but small section, and extremely fine lines; and it could then be moored more easily, than a floating body of the circular form now proposed. It was a strong objection, that it presented an enormous section to the action of the waves, the tide, the current, and the wind. The smaller constructions appeared to have succeeded, but in exact

proportion as they became larger, would arise the difficulty of providing adequate moorings. There would be such an enormous strain on the centre, that something much stronger than was indicated in the diagrams, would be absolutely necessary. He also feared, that with such a shape, the chain would chafe very much on the edges of the vessel. He believed it would be better to make it tapering both above and below water-line, rather than with vertical sides; it would then combine the greatest stability with the greatest ease of motion. The main point, however, was whether any mooring could keep it in its place, and whether, with such moorings, it could be handled; and he had no doubt that these purely mechanical difficulties could be easily overcome.

There was not any analogy between a vessel with all her sails set and the sea-light; the vessel never had all her sails set whilst at anchor, nor in such a heavy gale of wind as would affect the sea-light. The comparison was therefore delusive and useless.

Mr. Herbert observed, that no such chafing had as yet taken place, in the buoys already laid down, and that which had occurred in the experimental beacon, arose from a palpable error in construction.

Admiral Beachey said, that the Board of Trade had determined on making an experiment, by placing a large beacon, constructed on Mr. Herbert's plan, in an exposed position on the South-West coast of Ireland. If it were attended with success, it would doubtless be a great boon to mariners.

Captain Gordon, R.N., observed, with reference to the two, or three light-ships, which had parted from their moorings, that it was a rare accident, and had occurred in a year of remarkable casualty among shipping. All the light-ships had, however, been saved, either by letting go their anchors, or by making sail for the nearest ports. He apprehended, that if a similar accident should happen to a vessel of the circular form, now proposed, the safety of the men on board would be much endangered. He admitted that the system was admirable for buoys; it had proved highly successful, and he hoped it would be further tried.

Mr. Rogers begged to inquire, in reference to a phrase used by one of the previous speakers, where was the 'broadside' of the circular body under discussion? He apprehended, that when moored from the centre, there could not be much oscillation, and there would be less probability of its being injured, if struck by heavy seas.

Mr. Herbert said, that the beacon at the South Sand Head, which was 20 feet in diameter, and, consequently, had considerable side surface, exposed to the action of heavy seas in a bad situation, did not incline more than 10° from the perpendicular.

Mr. Bayliss thought, that with regard to the action of the wind, no fair comparison as to the amount of resistance could be drawn, between a 52-gun ship, as represented, with all sails set, and a structure of the character proposed; inasmuch as, in a gale of wind, the sails would be close furled and the top-masts lowered. Moreover, the ship would yield to the action of the wind and tide, whilst the beacon would not do so, being held stationary by its moorings. He had considerable doubts as to the safety of a circular-shaped vessel, opposed, as it was, to the experience of four thousand years; he approved of the principle of central attachment for the mooring cables, if it were carefully executed; but would not sacrifice every other principle to that of the attachment. He would suggest the prudence of carrying out the principle, with a view to practical result, rather than strict adherence to theory. He should prefer a vessel approaching somewhat to the ordinary shape, for the base, or say elliptic instead of circular, (100 feet long, and 70 feet broad,) with the point of attachment $\frac{4}{9}$ths or $\frac{3}{7}$ths of the length from the head; this arrangement would allow of the vessel veering round, so as to expose its smallest sectional area to the action of the wind and tide.

He feared, that in depths beyond the limits of Mitchell's screw-moorings, there would be difficulty in securing a permanent hold,—that great difficulty would be found in providing adequate gearing, and in handling the chain;—and if the vessel should once part from its moorings, the great height of the tower would offer such leverage, or purchase to the wind, as would cause it to capsize. He, therefore, suggested the expediency of constructing about 40 feet of the upper portion of the tower, on the telescopic principle, so as to admit of its being lowered, during a gale of wind, into the lower part, and brought nearer to the centre of gravity. It had been objected, that the lights might possibly be extinguished by the continued oscillations of the tower; but this could be obviated, by the employment of 'gimbles,' or universal joints for their suspension. It was also feared that, if placed in mid-channel, it might become an obstruction to the navigation, in foggy weather; but this might be avoided, by mooring it on one side of the channel.

He further suggested, that in the event of its capsizing, it might be possible to keep it afloat, by reducing the thickness of the external plates of the tower, forming it of two concentric rings, or plates, and thus building it in water-tight compartments. He thought, that a steam-engine would be found a useful auxiliary, for handling the gearing and cable, for pumping out the bilge, for lowering the sliding top of the tower, which he had proposed, and for rendering the vessel secure, in the event of a leak. A

screw-propeller might also be advantageously added, if practicable, in order to counteract the effect of the wind and tide, and to reduce the strain upon the cable.

Captain HALSTED, R.N., had listened with great interest, to the proposed extension of Mr. Herbert's system to sea-lights. With the exception of Captain Washington, who appeared to have supported and appreciated the undertaking, the remarks, hitherto made, had been of a tendency to discourage, rather than to assist the adoption of a plan, which, if carried out successfully, would, in his opinion, prove, not merely an innovation, but a real progress. The nautical gentlemen who had spoken, had not, in his opinion, sufficiently reflected, that the essential principle of the proposed plan, was the mooring, or attaching vessels from their centre of gravity: a method of which, hitherto, little, or no practical experience had been acquired. Their knowledge, therefore, was limited to the mooring of vessels from the bows, or from the point farthest from the centre of gravity, since it was by this end suspension, that all ships had, hitherto, met the effects of heavy seas and tides. A vessel thus moored, received the full force of the wave, with her nose, as it were, held down to the blow, while the after-part was comparatively free to move to any extent; but a ship, centrally moored, would be equally free to move in all directions, and he apprehended, that it was impossible to establish any analogy between two vessels moored under circumstances so dissimilar, nor was it possible to infer from the one, what would be the effect of the action of the sea on the other. In default, therefore, of actual experience of central suspension, as applied to ships, the only practical guide was the flotation and the perpendicularity maintained by these buoys, and the beacon constructed on this principle. Now it appeared, that the buoys had remained clearly visible, under circumstances of heavy sea and bad weather, where larger buoys, of the ordinary construction, were almost useless. If, therefore, a beacon, of 20 feet diameter, had fulfilled all the conditions required, and had maintained a conspicuous and vertical position, on account of the combined advantages of the form of construction, and of the point of attachment of the mooring, it would be difficult to understand, why any different effects should result from the extension of the scale of construction; there being nothing in practice, or experience, to warrant such a conclusion. It might not, perhaps, be advisable to extend the dimensions too rapidly at first, but gradually to increase the scale, to diameters of 40 feet, 80 feet, and 100 feet; and from the success already obtained, he felt that there was every encouragement to proceed.

But there were some distinct points of difference between the two systems of mooring, which presented themselves for consi-

deration. For instance, it was sometimes necessary for the safety of a ship, that she should lift and drop her anchor, several times in one day; and, consequently, it was essential that all her gear, cables, &c., should be of such a size and weight, as would admit of their being easily handled, for security to a ship in bad weather was gained by the elasticity due to the length of scope of the cable, rather than by the absolute power of the cable itself rigidly to resist the strain; and thus circumstances and conditions were produced, which, he believed, would not be found to apply to the case of a centrally-moored body, such as that proposed. For this great scope allowed the cable to assume a long catenary curve, the tautening and slacking of which in a gale of wind, caused the ship to be continually in motion a-head and a-stern, and the eventual strain brought upon the cable, was thus mainly due to the ship's momentum. Now a vessel moored from the centre, and intended to be as stationary as possible, would only require a length of chain sufficient to allow for the vertical rise of tides and waves, and thus the cable would not permit the same extent of motion as in the ordinary ship. Again, since a ship presented her finest proportions in the direction of the resistance, and was thus the more easily driven a-stern, so her very form thus assisted in bringing her momentum to augment the strain upon the cable. Whereas, a vessel of the form and dimensions proposed, not being easily moved, and with little room for motion, would acquire little, or no momentum from the action of the wind, or the sea, and the cable would chiefly have to meet the vertical rise and fall of the waves.

Objections had been made to the proposed form of this vessel; but it must be borne in mind, that it was not constructed for going through the water: the very essence of its qualifications consisting in its remaining as stationary as possible. If it were constructed of the ordinary form of a vessel, as to length and breadth, as had been recommended, was it certain that, when moored from the centre, she would always present herself with the smallest section in the direction of the resistance? Did not experience justify the belief, that she would most likely lay broadside to the resistance? If it were found possible to moor ordinary ships centrally, letting go their anchors from midships, instead of from the bows, his impression was, that the first necessity which would arise, would be an alteration in the present form and the adoption of a circular shape, as the ships would no longer be acted upon by the waves and winds, in the same way as at present. He could quite understand, that with heavy tides in rivers and in places where the sets were very regular and strong, the question, whether the sea-light should be of an oblong, or of a circular form, might well be entertained. But he did not think that, practically, such a question

would ever arise; in his opinion safety-lights were not required in the middle of narrow channels; such channels would be best navigated by guiding-lights, so placed as to be seen from one side to the other. It was only for wide channels, that Mr. Herbert had proposed the central safety-lights, and it was in these situations, that they were most required, and could be best employed.

It had been urged against the adoption of these central lights, that, if they broke adrift, the lives of the men on board would be exposed to great danger. But even if such were the inevitable consequence, there surely could be no insurmountable difficulty in preparing for such a contingency; nor ought this risk to furnish any argument against adopting a system of safety-lights, which might be the means of preserving thousands of human beings. Nearly one thousand lives were annually lost upon the British coasts, from shipwreck alone, and although these wrecks were not all attributable to the want of safety-lights, yet he could not doubt, that many of them might have been prevented, if such lights had been in existence.

With regard to the danger, to which the people on board were exposed, in the event of getting adrift, the same remarks would apply in every case where a life-boat was launched, for the purpose of rescuing persons from a wreck, for there was danger of casualty, even with the life-boat. This seemed to be the principal objection raised by some nautical men to these safety-lights; yet it was admitted, that, otherwise, they offered a great desideratum for the safety of the shipping on the coast. But there was no reason why these circular beacons and sea-lights should not have spare anchors, to let go in case of emergency, nor was it absolutely certain that, if they did break adrift and run ashore, all the people on board must necessarily perish; constructions in iron were now made so strong, as to resist the action of any seas, for a sufficient length of time to save the lives of the people, if in almost any position.

Difficulties had been assumed with regard to the mooring, which he did not think existed. It was not an uncommon thing to see heavy ships ride out a severe gale, with their cables secured round the windlass. He saw no reason why circular or endless bridle-chains, attached to very heavy ground tackle, by being rove through strong broad mooring-rings, should not be coiled with one, or more turns around a windlass of sufficient strength, which might be worked by machinery, capable of being managed by even one man. The light-vessel might thus have any required number of double moorings, and whatever might be the weight of the cables, as one side would balance the other, the power for working the windlass would chiefly become a question of friction. Such an arrangement would give every opportunity of inspecting the chains at all times, and seeing that all the links were secure.

He thought, if these safety-lights could be brought into operation, they would afford double security to navigation in all narrow and dangerous waters. Vessels could be worked with great confidence and safety, in channels, where the seamen could then pass close to a safety-light, and even read its name and ascertain its latitude and longitude, under circumstances where they now often had to grope their way in uncertainty. He thought, that the adoption of this system would be the inauguration of a new era in navigation, the benefits of which it was impossible fully to estimate.

Captain GORDON disclaimed any unfriendly feeling towards the project. He admitted, that the new buoys were an admirable invention; but he was not yet satisfied, that the principle could be carried out to the extent proposed, or that it would answer so perfectly as had been presumed. It was a new theory, and had never yet been tested on a large scale.

Captain SHEPHERD corroborated Captain Gordon's views. The Corporation of the Trinity House, to which he belonged, was most anxious to give every encouragement to the system of construction introduced by Mr. Herbert, as far as it could be considered useful; advantage had been taken of it, for the construction of buoys, and it was strongly recommended for that purpose; but at present, it was not considered sufficiently proved, to allow the form to be adopted for light-ships. He did not pretend to give an opinion as an Engineer, but simply as an old practical sailor. The great objection appeared to arise from the form of the proposed vessel. He felt, that if this plan had been hastily adopted by the Trinity House, and an accident had occurred in St. George's Channel, by which three or four lives had been lost, the Corporation would have been blamed, for not having previously tried the system upon a smaller scale. The question was not so much, whether a circular vessel, moored from the centre, would ride more easily than an ordinary ship, as whether the advantages of this description of light-vessel, were such as to counterbalance the existing disadvantages. Allusion had been made to the breaking adrift of the present light-ships; but this had not occurred, of late years, to the extent of more than one, or one and a half per annum; and he doubted whether there would have been fewer casualties, if the whole of the light-vessels had been of a circular form, more especially had they been placed in mid-channel, where there was danger of collision, in thick and foggy weather. Danger, from this source, would be very great, to any ship moored in the centre of St. George's Channel, which, being the great highway to Liverpool, was traversed by thousands of vessels every year. Every one knew the effect of a vessel going eight, or ten knots an hour, coming into collision with another body, moving, or stationary, however strong; that was a contingency which it was important to

consider. One great advantage of the present light-ships was, that if they broke adrift, they could easily be brought up, whereas there could not be the same facility in handling a vessel of a circular form, and there would not be any possibility of replacing her on her station, except by means of a powerful steam-tug. Thus a week might elapse, before she could be brought back again into her proper position, and, meanwhile, passing vessels would be misled; they would look out for the safety-light, and, in its absence, might fall upon a lee-shore, and be driven amongst the breakers. Therefore it was not altogether the peril to the lives of those on board, which prevented its adoption, but the fear, lest it might prove a source of danger, instead of a means of safety to the navigator. He thought the new buoys were eminently successful, and would prove of great service, by being placed where light-ships could not well be employed; but when it was proposed to extend the plan to floating light-houses, the difficulties were not at present so far obviated, as to justify him in recommending its adoption. With regard to examining the cables of light-ships, that was a duty, which was strongly enforced upon the keepers of those at present in use, and the strongest proof of the efficiency of that class of vessels was, that, as had already been stated, not more than an average of one, or one and a half, broke adrift in the course of twelve months. The greatest number in any one year was three, and that was attributable to the effects of the intense frost: the chains and links were found to break, at that time, with eight, or ten blows, whereas, under ordinary circumstances, they would require a hundred and fifty, or two hundred blows to fracture them. As to the wrecks on the coasts, he believed, that if the causes were strictly investigated, it would be found, that not one in five hundred, or a thousand, could be fairly attributed to the insufficiency of lights. In the majority of instances, they resulted from carelessness on the part of the persons in charge of the ships, who frequently ran heedlessly on, without keeping any look-out; and also from the fact of many vessels being badly 'found,' and miserably 'manned.' He agreed with Captain Halsted, that in narrow waters, it was desirable to have beacons, or lights which might be run up to; the Trinity House had endeavoured to effect that object, as far as possible, and they approved, to some extent, of leading-lights, placed on the point of danger. He did not think the suggestion of a sliding-top to the tower, would be found to answer, inasmuch as the means employed for lowering and raising it, must, of necessity, be somewhat complicated, whilst the great objects to be obtained, in such a structure, were simplicity and strength: neither did he think it would be advisable, or even possible, to employ a steam-engine or propeller, for the purposes

suggested. The Corporation of the Trinity House had the most friendly feeling towards the proposed form of buoys and beacons, and they would gladly hear of some method of obviating the difficulties which were apprehended, and for rendering the plan safe and practicable, if possible, for light-ships; at present, he feared, these difficulties were greater than Mr. Herbert was inclined to admit.

Captain Halsted, R.N., admitted the great care and vigilance bestowed, by the Trinity House, upon all the matters under their charge; but still, in bad weather, lights were frequently missed. He would particularly notice the 'Owers' light, between the Thames and Spithead, which was so placed, that vessels were often afraid to run for it; not only merchantmen, but vessels of the Royal Navy, had found themselves at the back of the Isle of Wight, from not having seen the 'Owers' light at all. He thought the adoption of this plan, would double the security of navigation. There would be little fear of collision, even in foggy weather, for the light would still be visible at least a cable's length from the vessel; and with regard to misleading vessels in the event of its getting adrift, he apprehended, that under such circumstances, the light would inevitably be extinguished.

Captain Shepherd observed, that it would not be possible to cut away the tower, which would be easily seen during the day-time, and might mislead vessels, till it could be replaced in its proper situation: whereas the present light-ships could be immediately removed, when drawn out of their proper stations.

Mr. Croker mentioned, that the Dutch government had experienced considerable difficulty, in protecting the entrance to a harbour on the North-West coast of Holland, and they had, at last, recourse to a system of floating breakwaters, which occasionally drifted away, owing to the fretting and fracture of the links. It was intended to institute experiments upon the principle of central mooring, which had been rudely attempted in the Dutch East Indian possessions, and was considered the best means of enabling a body to float permanently. An interesting Paper on the subject, would be found in the "Transactions of the Institution of Civil Engineers of Holland." He could not approve of placing a telescopic top to the tower, as it was precisely in the worst weather, that the light was most wanted, and then, at the greatest possible elevation above the level of the sea.

Mr. Herbert expressed his thanks for the kind reception of his Paper, and his gratification at the tone of the discussion which had taken place, which induced him to hope that the principle he had proposed, would be progressively extended and prove useful.

Mr. Simpson,—President,—was sure the Author must be gratified by the kindly spirit and good feeling, which had characterised

the discussion, and expressed a hope, that it would direct attention to the means of improving light-ships, and to supplying the great want of mechanical appliances in the working of ships, if what had been stated, as to the difficulty of managing upwards of 100 fathoms of chain cable, was correct. There might be some difficulty in handling that length of chain, only weighing about 25 tons, on board a vessel, but an Engineer would not consider it any very formidable undertaking, even with very simple means. He believed, that greater attention was now being paid to the construction of iron work for ships, and no doubt great benefit would be derived to navigation, by more frequent and friendly intercourse between engineers and sailors.

Silvered Porcelain Reflectors.

Captain Washington, R.N., took advantage of the opportunity, to direct the notice of the Institution, to a new kind of Reflector for Lights, which had been transmitted to him by the Hon. Major Fitzmaurice, who had taken great interest in its introduction and in perfecting the manufacture. It was composed of silvered porcelain, burnt in, and appeared to possess a very brilliant polish, which was stated to be quite indestructible.

The question of reflectors was very intimately connected with the subject just discussed.

There were three hundred and twenty Lighthouses on the coast of Great Britain alone, and new ones were constantly in course of erection, in different parts of the world. The vast shores of Australia were in great need of lights, and it was of the utmost importance, that the reflectors should be of the best possible description. Those at present in use were very unsatisfactory, and of those hitherto supplied to the West Indies, many had been returned; those of metal silvered were injured, and eventually rendered useless, by constant cleaning. The new reflector, recently introduced by the Hon. Major Fitzmaurice, was of brown porcelain, burnt in, and silvered on the inside, and in the comparative trials with metal reflectors at Mr. Wilkins', had proved perfectly successful. The largest which had hitherto been produced, was 12 inches in diameter, but some of 21 inches diameter were now in progress. This species of reflector could be produced at about one-tenth of the ordinary cost of those of metal, and there was every reason to believe, that they would prove very effective, and nearly indestructible, except by accidental fracture.

Mr. Gordon said, that it was most desirable to obtain a cheap and accurate reflector. Some were now being made for him, out